

**First-Generation Jet Propulsion Laboratory "Hockey-Puck"
Free-Flying Magnetometers
for Distributed *In-Situ* Multiprobe Measurement of Current Density Filamentation
in the Northern Auroral Zone: Enstrophy Mission**

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The Enstrophy sounding rocket mission is a collaborative project between the University of New Hampshire, Cornell University, and the Jet Propulsion Laboratory (JPL) to study filamentation phenomena in the northern Auroral zone. The Enstrophy mission will test fly the JPL Free-Flying Magnetometer (FFM) concept. The FFM technology development task has been funded by NASA / JPL to develop miniaturized, low-power, integrated "sensorcraft". JPL's role is to design, integrate, test, and deliver four FFMs to be deployed from the sounding rocket, allowing a unique determination of curl-B. This will provide a direct measurement of magnetic-field-aligned current density along the rocket trajectory.

A miniaturized three-axis flux-gate magnetometer is integrated with 22-bit ADC, four temperature sensors, digital electronics, seven (Li-SOCl₂) batteries, two (4° × 170° field of view) sun-sensors, 4 nutation dampers, a (fan-shaped beam) laser diode beacon, a (16 MHz) stable Temperature Compensated Crystal Oscillator (TCXO) clock, a data communication subsystem, and an antenna for approximately 15 minutes of operation which consists of three (3) data gathering phases interleaved with bursts of data transfer (approximately 30 seconds each) to ground station antennas (TOTS) at Poker Flat, Alaska. FFMs will be stowed within two trays onboard the rocket during the rocket launch and will be released simultaneously using the spinning action of the rocket at approximately 300 km altitude. FFMs will be deployed with spin rate in the range of 8-11 Hz with 2- 3 m/sec linear velocity with respect to the rocket. While the rocket is in the launch pad and prior to release of FFMs from the rocket, commands (such as "power on", "test", "flight", "power off", and clock reset signal) are transmitted via a infrared Light Emitting Diode to a infrared detector in the FFM. Special attention was paid to low magnetic signature system design and choice of materials in packaging. Miniaturized flux-gate magnetometers have a range of 1-65536 nT with 0.1% full-scale linearity. The frequency range of interest for magnetic measurement is 10 mHz - 50 Hz. Digital data from the magnetometer's three axes are placed in a 4MB SRAM in data packages formatted together with time tags and frame ID. After a specified time is elapsed, the data are Viterbi encoded and transmitted at a rate of 100 kbps (BPSK). FFMs transmit at four different frequencies. The carrier frequencies are in the range of 2200-2300 MHz. The antenna is a single patch on a high dielectric constant substrate covering one end-plate of the "hockey-puck" sized unit. The local clocks aboard the FFMs are reset at the start of the mission and stay synchronized within 3 msec during the mission. Position of each FFM with respect to the rocket is calculated by the knowledge of its release velocity providing an accuracy of 1 m over the maximum range of 3 km. Spatial and temporal nature of observants can be separated to within 3 m in space or 3 msec time interval.